

*THE MOMENTUM OF HUMAN BEHAVIOR
IN A NATURAL SETTING*

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Adults with mental retardation in a group home received popcorn or coffee reinforcers for sorting plastic dinnerware. In Part 1 of the experiment, reinforcers were dispensed according to a variable-interval 60-s schedule for sorting dinnerware of one color and according to a variable-interval 240-s schedule for sorting dinnerware of a different color in successive components of a multiple schedule. Sorting rates were similar in baseline, but when a video program was shown concurrently, sorting of dinnerware was more resistant to distraction when correlated with a higher rate of reinforcement. In Part 2 of the experiment, popcorn or coffee reinforcers were contingent upon sorting both colors of dinnerware according to variable-interval 60-s schedules, but additional reinforcers were given independently of sorting according to a variable-time 30-s schedule during one dinnerware-color component. Baseline sorting rate was lower but resistance to distraction by the video program was greater in the component with additional variable-time reinforcers. These results demonstrate that resistance to distraction depends on the rate of reinforcers obtained in the presence of component stimuli but is independent of baseline response rates and response-reinforcer contingencies. Moreover, these results are similar to those obtained in laboratory studies with pigeons, demonstrating that the determination of resistance to change by stimulus-reinforcer relations is not confined to controlled laboratory settings or unique to the pigeon.

Key words: response rate, resistance to change, behavioral momentum, variable-interval schedules, variable-time schedules, response-reinforcer contingencies, stimulus-reinforcer relations, sorting behavior, humans

Behavior tends to persist under altered conditions once it has been established by a history of reinforcement in the presence of a discriminative stimulus. This persistence suggests that discriminated operant behavior may be construed as having momentum. The momentum metaphor for behavioral persistence has been fruitful in both basic and applied analyses. This article reports the application to humans (in a naturalistic setting) of basic research paradigms for the study of behavioral momentum that have been developed with nonhuman subjects.

In classical mechanics, momentum is defined as the product of the mass and velocity of a moving body. The change in its velocity when a given external force is applied is inversely proportional to its mass. Thus, the velocity of a heavy body is more resistant to change than that of a light body. Nevin, Mandell, and Atak (1983) suggested a parallel for free-operant behavior: Baseline rate of responding is analogous to velocity, and the resistance of that rate to change by a separate operation serves to assess the analogue to mass.

In applied work, one goal of treatment is to establish and maintain desirable behavior at a high rate in the presence of appropriate stimuli and to ensure persistence of that behavior in related situations after treatment is discontinued. In terms of the momentum metaphor, the goal is to establish both high velocity and large mass, which combine to give high behavioral momentum. Thus, it is important to identify the determiners of both response rate and resistance to change.

Experimental studies with pigeons, rats, and monkeys have demonstrated that resistance to the rate-decreasing effects of procedures such as extinction, reduced deprivation, alternative reinforcement, punishment, and conditioned suppression is an increasing function of the rate, amount, or immediacy of reinforcement obtained in the presence of a discriminative stimulus and the duration of the reinforcement history (see Nevin, 1979, 1988, for review). For example, Nevin (1974; see also Nevin et al., 1983) arranged multiple variable-interval variable-interval (multiple VI VI) schedules with different rates of reinforcement in two

successive schedule components signaled by distinctive stimuli. Under these conditions, resistance to change, assessed by presenting free food between components or by extinction, was greater in the component with the higher rate of reinforcement. However, multiple VI VI schedules confound the rate of response-contingent reinforcers with the overall rate of reinforcer presentation in a component, so that the effects of response-contingent reinforcers and stimulus-reinforcer relations cannot be separated.

Some recent studies have suggested that maintained response rate (velocity) depends on operant, response-reinforcer contingencies, whereas resistance to change (mass) depends on Pavlovian, stimulus-reinforcer relations (Nevin, 1984; Nevin, Smith, & Roberts, 1987; Nevin, Tota, Torquato, & Shull, 1990). For example, Experiment 1 by Nevin *et al.* (1990) with pigeons arranged identical VI schedules of food reinforcement in two schedule components and also arranged concurrent response-independent reinforcement according to variable-time (VT) schedules in one component (conc VI VT). This procedure weakens the response-reinforcer relation in the component with added VT reinforcers because not all reinforcers are contingent on responses. At the same time, it strengthens the stimulus-reinforcer relation in that component because more reinforcers occur in the presence of its component stimulus. Baseline response rates were lower but resistance to change was greater in the component with added VT reinforcers, consistent with the notion that response rate is determined by response-reinforcer contingencies whereas resistance to change depends on stimulus-reinforcer relations.

In a group home setting, Mace *et al.* (1988) used the momentum metaphor to suggest a way to establish compliance with requests in retarded humans. They reinforced compliance with requests that were likely to be obeyed and then observed persistent compliance with requests that ordinarily were not obeyed. In relation to the notion of behavioral momentum, their work suggests that when several instances of a response class (compliance) have occurred and have been reinforced, the class gains momentum so that other members of the class become more probable in related conditions.

The paradigm used by Mace *et al.* (1988) differed from that used by Nevin and his as-

sociates in several ways. In particular, Mace *et al.* arranged continuous reinforcement for compliant behavior, with the result that response rates and reinforcer rates were interdependent. Thus, response rate cannot be separated from the consequences of responding in the determination of resistance to change. By contrast, the multiple VI VI schedules used by Nevin and his colleagues ensured that obtained rates of reinforcement were largely independent of component response rates, so their effects could be separated.

Here, we report data on resistance to change of an everyday activity of humans with mental retardation in a group home setting. The experimental paradigms are modeled on those used by Nevin and his colleagues with pigeons in controlled experimental sessions, but resistance to change is assessed by a method (distraction by television) that is relevant to natural human situations. Part 1 of the experiment asks whether resistance to distraction of human performance in the group home setting depends on reinforcer rates in the components of multiple VI VI schedules in the same way as does resistance to change of nonhuman performance in controlled experimental settings (e.g., Nevin, 1974). Part 2 asks whether resistance to distraction of human performance in the group home setting is enhanced by additional response-independent reinforcers in one schedule component in the same way it is for pigeons in experimental settings (Nevin *et al.*, 1990).

These studies bear upon both basic and applied issues in the analysis of behavior. With respect to basic issues, Pavlovian determination of resistance to change has been suggested by experiments with pigeons as subjects, keylights as stimuli, key pecking as the response, and food as the reinforcer. There is reason to believe that pigeons are biologically predisposed to peck at localized visual stimuli signaling food in Pavlovian fashion (Schwartz & Gamzu, 1977). Therefore, replication with other species, stimuli, responses, and reinforcers is needed to ascertain whether the processes determining resistance to change are unique to biologically prepared relations.

With respect to applied issues, McDowell (1982, 1988) has shown that concurrent alternative reinforcement decreases the rate of unwanted behavior, regardless of whether it is contingent on an explicit competing response

or is independent of responding. However, Nevin et al. (1990) showed that although concurrent reinforcement decreased baseline response rate in a schedule component, it also enhanced resistance to change in that component. Similar results with humans in an applied setting would suggest that alternative reinforcement may not be a desirable method for reducing unwanted behavior: Although it may decrease the rate of unwanted behavior, it may also increase the persistence of that behavior. The following experiments address these basic and applied issues.

METHOD

Subjects

Subject 1 was a 38-year-old male with a diagnosis of severe mental retardation (IQ = 36). He spoke in complete sentences using a limited vocabulary and routinely followed one- and two-step instructions. No physical handicaps that might interfere with manipulating the task materials were apparent. The subject's psychiatrist prescribed 10 mg of Haldol b.i.d. to control episodic aggression. The subject had resided in large, state-operated institutions from the age of 6 to 33 years old.

Subject 2 was a 45-year-old male who scored in the low average range of intellectual functioning (IQ = 75). His expressive and receptive language was normal. Due to a history of delusional and threatening speech, Subject 2 resided most of his life in hospitals and institutions. He received 100 mg of Mellaril b.i.d. for these behavior problems. At the time of the present study, both subjects had lived in a university-affiliated community group home for approximately 3 years. Both subjects volunteered to participate in the study and cooperated fully.

Setting and Materials

Sessions for Subject 1 were conducted in the kitchen of the group home. The subject was seated at the end of an oblong table (1 m by 2 m) with the experimenter on his left and one or two data collectors on his right. A randomly shuffled pile of 40 red or green plastic eating utensils and a cylindrical container (10 cm diameter, 14 cm high) were positioned on the table in front of the subject. The experimental task, sorting, consisted of removing utensils from the pile one at a time and placing the

pieces in the container. Reinforcers were five kernels of popcorn handed to the subject in a small plastic cup.

Sessions for Subject 2 were conducted in the subject's bedroom. The subject sat at a 1-m square table opposite the experimenter and next to one or two data collectors on his left. The materials and nature of the sorting task were identical to those described for Subject 1. The reinforcer consisted of handing the subject a transparent measuring cup containing 50 mL of black coffee.

Response Measures and Data Collection

The dependent measure for both parts of the experiment was the rate (per minute) of sorting responses. A sorting response was defined as the cycle beginning with lifting a utensil from the pile and ending with the utensil touching the bottom of the container. The independent variables were response-dependent reinforcement (Parts 1 and 2) and response-independent reinforcement (Part 2). The former was defined as the experimenter handing a cup of popcorn or coffee to Subjects 1 and 2, respectively, within 2 s of a sorting response. The definition of the latter consisted of presentation of the reinforcer cup when the subject (a) did not have a utensil in hand and (b) had not placed a utensil in the container within the last 5 s.

Dependent and independent variables were measured by a human observer using a count within 10-s interval recording procedure (Johnston & Pennypacker, 1980). A second independent observer collected data during a minimum of 35% of the total sessions, including at least one session during both distracting stimulus phases. Interobserver agreement on response and reinforcer occurrences was calculated on a point-by-point basis by dividing the number of agreements by the number of agreements plus disagreements and multiplying by 100%. Mean occurrence agreement for the dependent and independent variables was 91% or higher for both subjects.

Procedure

Baseline. Reinforcement was arranged using a multiple-schedule procedure. Daily sessions consisted of four 3-min components, two each using exclusively red or green utensils. Red and green utensil components were presented in random order each session and separated

by 2-min intervals devoid of materials, reinforcers, and social interaction. During Part 1 of the experiment, sorting responses for Subject 1 were reinforced on a VI 60-s schedule during red utensil components, and sorting during green utensil components was reinforced on a VI 240-s schedule. The reinforcer-color pairing was reversed for Subject 2. The experimenter began each component with the instruction, "You can sort for popcorn (or coffee)" and handed one utensil to the subject. The experimenter provided neither approval nor disapproval of the subjects' behavior during or after sessions. Components ended with the experimenter saying, "Okay, you can take a break."

During Part 2 of the experiment, a VI 60-s schedule of reinforcement was in effect during both red and green utensil components. However, in addition to the VI 60-s schedule, response-independent reinforcers were delivered on a VT 30-s schedule during the red component for Subject 1 and during the green component for Subject 2 (i.e., a conc VI VT schedule).

Reinforcer deliveries were scheduled using an audiotape played into an earphone worn by the primary observer. Simultaneously with the subject's first sorting response after the response-dependent reinforcement interval was signaled, the observer rang a kitchen timer in order to make clear to the subject the contingent relationship between reinforcer deliveries and sorting responses. For response-independent reinforcement, the observer rang the timer as soon as the subject was not engaged in a sorting response (according to the definition above). Immediately after the timer rang, the experimenter promptly handed the subject the reinforcer cup. Reinforcers were not in the subject's field of vision at other times. Inter-reinforcement intervals (IRI) were randomized in both components with ranges of 15 s to 45 s, 30 s to 90 s, and 120 s to 360 s during the VT 30-s, VI 60-s, and VI 240-s schedules, respectively. Timing of the component duration stopped when the subject touched the reinforcer cup and resumed when the experimenter handed a utensil to the subject.

Concurrent distracting stimulus. This condition was designed to assess resistance to change under mult VI VI (Part 1) and mult VI VI/VT (Part 2) schedules of reinforcement. The baseline multiple-schedule procedure

remained in effect while a distracting stimulus was presented concurrently. The distracting stimulus was a videotape of action excerpts from a popular music/dance television program played at moderate volume on a 33-cm color television positioned 1.5 m in front of the subject at eye level. The videotape was played during the entire component, including during reinforcer deliveries, and was turned off during the intervals between components.

Experimental Design

For both subjects, the multiple-schedule baseline procedure (A) and concurrent distracting stimulus procedure (B) were presented according to an ABAB experimental design. Baseline phases continued until stability was evident visually and were followed by two sessions of the concurrent distracting stimulus condition.

RESULTS

Figure 1 shows response rates for both subjects under baseline and concurrent distracting stimulus conditions during Part 1 of the experiment. The baseline multiple-schedule VI 60-s VI 240-s procedure resulted in very similar response rates across schedules, baseline phases, and subjects (see Table 1). One exception was the increased response rate from Baseline 1 to Baseline 2 evident in both components for Subject 2.

The effects of presenting a distracting stimulus concurrently with the sorting task assessed relative resistance to change under the two VI schedules. Responding during both VI schedules decreased while the videotape was played. However, response rates during the component with the higher rate of reinforcement (i.e., the VI 60-s schedule) were consistently higher than during the component with the lower reinforcement rate (i.e., the VI 240-s schedule). Further, response rates for both subjects were consistently lower during the second session of the distracting stimulus condition, indicating a progressive weakening of the effects of reinforcement during this condition.

Results of Part 2 are presented in Figure 2. During baseline conditions, sorting responses occurred consistently at higher rates for both subjects during the VI 60-s schedule than during the VI 60-s VT 30-s schedule (see Table 1). The proportion of the overall baseline VI

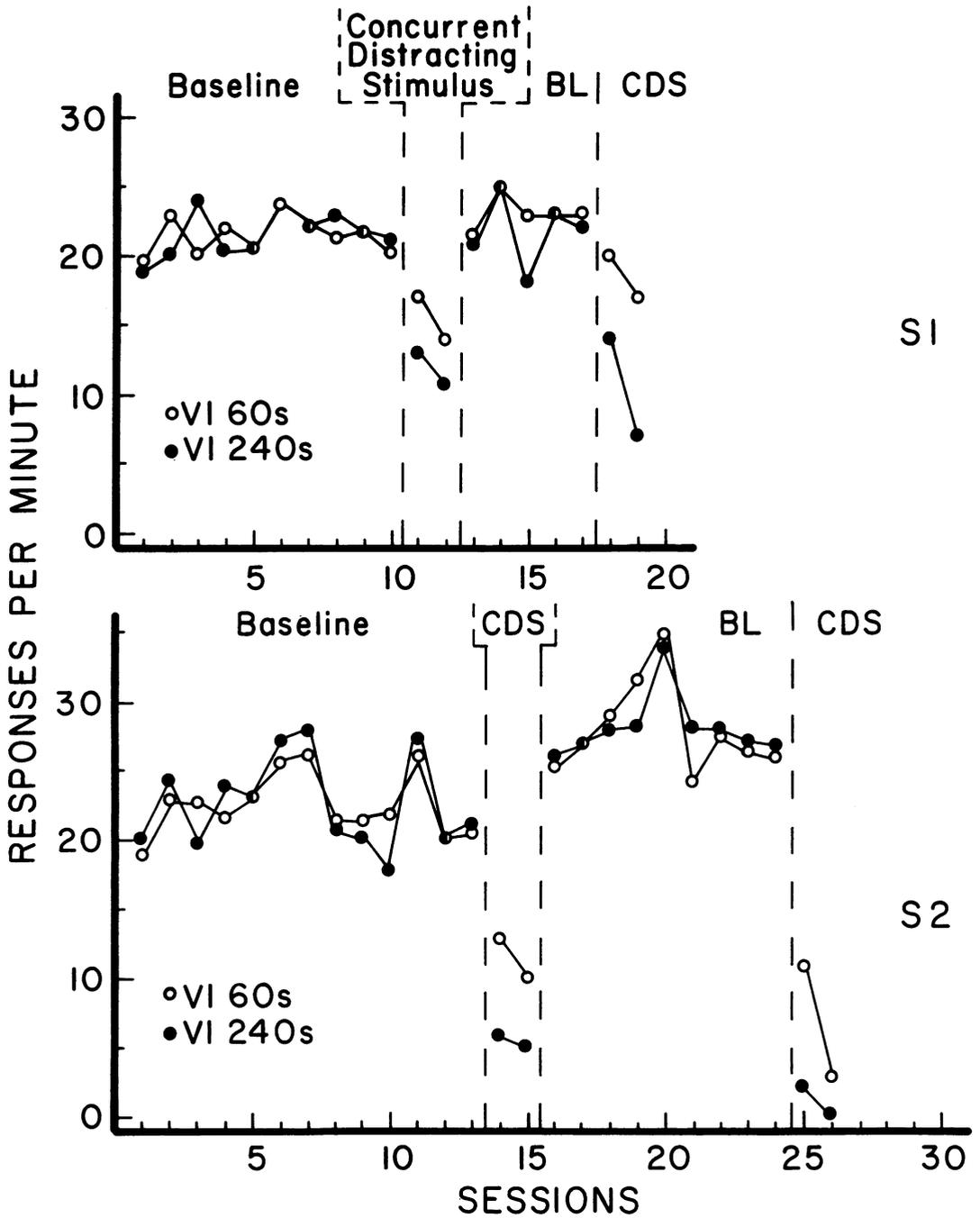


Fig. 1. Rate of sorting responses (per minute) for Subjects 1 and 2 during VI 60-s and VI 240-s components of a multiple schedule. Response rates are presented across two baseline and concurrent distracting stimulus phases.

60-s response rate observed during the baseline VI VT schedule was .89 and .74 for Subjects 1 and 2, respectively.

The ordinal relationship between response

rates in the two components was reversed for both subjects during the two phases of the concurrent distracting stimulus condition. Subjects responded at a higher rate under the conc

Table 1

Mean responses per minute during baseline and concurrent distracting stimulus (CDS) conditions for Parts 1 and 2 of the experiment, and median pigeon subjects during baseline and free-feeding (FF) (Nevin *et al.*, 1983) or prefeeding (PF) (Nevin *et al.*, 1990). CDS, FF, and PF means are also expressed in parentheses as proportions of baseline response rates.

Experimental condition	Subject 1			Subject 2		
Part 1						
Baseline 1, 2, <i>M</i>						
VI 60 s	21.5,	22.9,	22.2	22.4,	28.0,	25.2
VI 240 s	21.8,	21.9,	21.9	22.5,	28.2,	25.4
Concurrent Distracting Stimulus 1, 2, <i>M</i> (Proportion of baseline)						
VI 60 s	15.4,	18.7,	17.1	11.5,	6.8,	9.2
	(.72)	(.82)	(.77)	(.51)	(.24)	(.37)
VI 240 s	11.9,	10.9,	11.4	5.4,	1.3,	3.4
	(.55)	(.50)	(.52)	(.24)	(.05)	(.13)
Part 2						
Baseline 1, 2, <i>M</i>						
VI 60 s	22.1,	22.4,	22.3	28.0,	28.2,	28.1
VI 60 s	20.0,	19.0,	19.5	21.3,	19.9,	20.6
VT 30 s						
Concurrent Distracting Stimulus 1, 2, <i>M</i> (Proportion of baseline)						
VI 60 s	6.8,	5.7,	6.3	4.4,	2.1,	3.3
	(.31)	(.25)	(.28)	(.16)	(.07)	(.16)
VI 60 s	20.9,	12.2,	16.6	11.8,	7.5,	9.7
VT 30 s	(1.05)	(.64)	(.85)	(.55)	(.38)	(.47)
Median pigeon						
Schedule	Nevin <i>et al.</i> (1983)		Nevin <i>et al.</i> (1990)			
	BL	FF	BL	PF		
VI 86 s	119.6	70.1 (.59)				
VI 360 s	105.9	30.2 (.29)				
VI 60 s			44.0	11.9 (.27)		
VI 60 s VT 30 s			37.8	17.0 (.45)		

VI VT schedule than with VI reinforcement alone during every session that included the distracting video stimulus. Further, response rates decreased relative to baseline, with one exception (Subject 1, first phase of conc VI VT reinforcement with the concurrent distracting stimulus). For both subjects, responding decelerated over the two sessions of the concurrent distracting stimulus condition, thus showing the diminishing effects of reinforcement in the presence of a competing stimulus.

Table 1 summarizes the results for both parts of the experiment expressed as mean response

rate and proportion of baseline by subject and experimental condition. Also indicated in Table 1 are results of median pigeon subjects, averaged over baseline and free-feeding sessions (Nevin *et al.*, 1983) or prefeeding sessions (Nevin *et al.*, 1990).

DISCUSSION

The results reported above demonstrate that (a) the resistance of human performance to distraction is a positive function of the frequency of reinforcement signaled by task-related stimuli (Part 1) and (b) this effect is independent of the baseline response rate and the response-reinforcer contingency (Part 2). These findings are entirely consistent with the basic research literature on nonhuman performance. This consistency is illustrated in Figure 3, which presents the results reported above and those of previous studies with pigeons in the same form. The upper left panel presents average response rates during baseline (BL) and distraction (CDS) conditions for each subject in Part 1 of the present experiment. The upper right panel presents data for the median pigeon in a study by Nevin *et al.* (1983) for a condition in which the ratio of reinforcer rates was 4:1, as in Part 1 of the present experiment. For the pigeons, resistance to change was assessed by presenting food during periods between schedule components; this produces effects that are similar to those of concurrent reinforcement for a competing task (e.g., Pliskoff, Shull, & Gollub, 1968), which may in turn be viewed as equivalent to distraction. The human and pigeon assessment procedures may be seen as similar in that both reduce the value of the programmed reinforcer relative to concurrent or successive alternatives. The data are similar in that baseline response rates differed relatively little and that responding decreased less in the presence of stimuli correlated with more frequent reinforcement.

The lower left panel of Figure 3 presents average response rates during baseline and distraction conditions for each subject in Part 2 of the present experiment. The lower right panel presents the data of the median pigeon in an identical experimental paradigm, in which resistance to change was assessed by prefeeding in the home cage before experimental sessions (Nevin *et al.*, 1990, Experi-

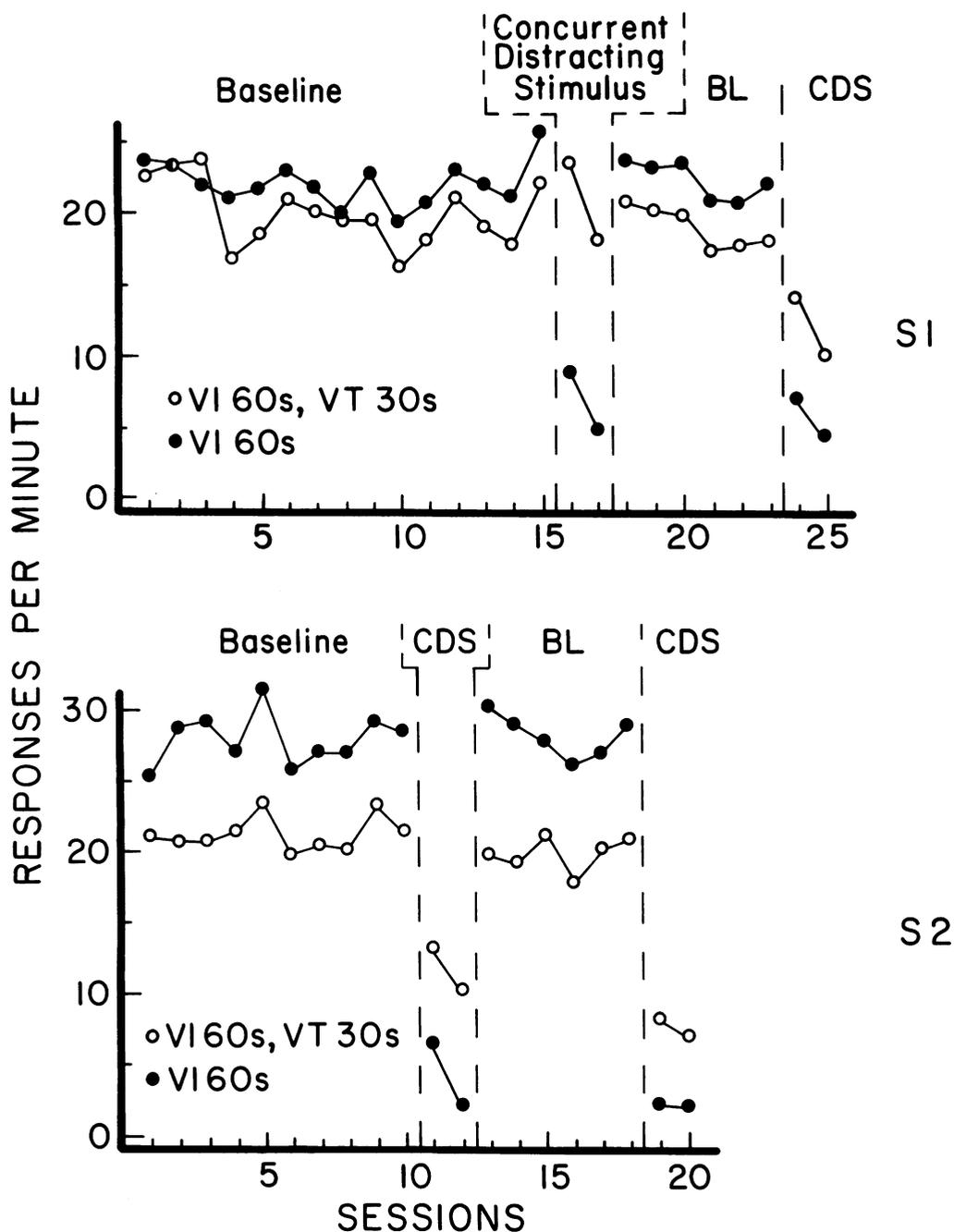


Fig. 2. Rate of sorting responses (per minute) for Subjects 1 and 2 during VI 60-s and conc VI 60-s VT 30-s components of a multiple schedule. Response rates are presented across two baseline and concurrent distracting stimulus phases.

ment 1). Nevin, Mandell, and Yarensky (1981) demonstrated that resistance to signaled reinforcement for an alternative competing response (analogous to distraction) was quan-

tatively similar to resistance to prefeeding, so the comparison is appropriate. The human and pigeon data are similar in that baseline response rates are lower but resistance to

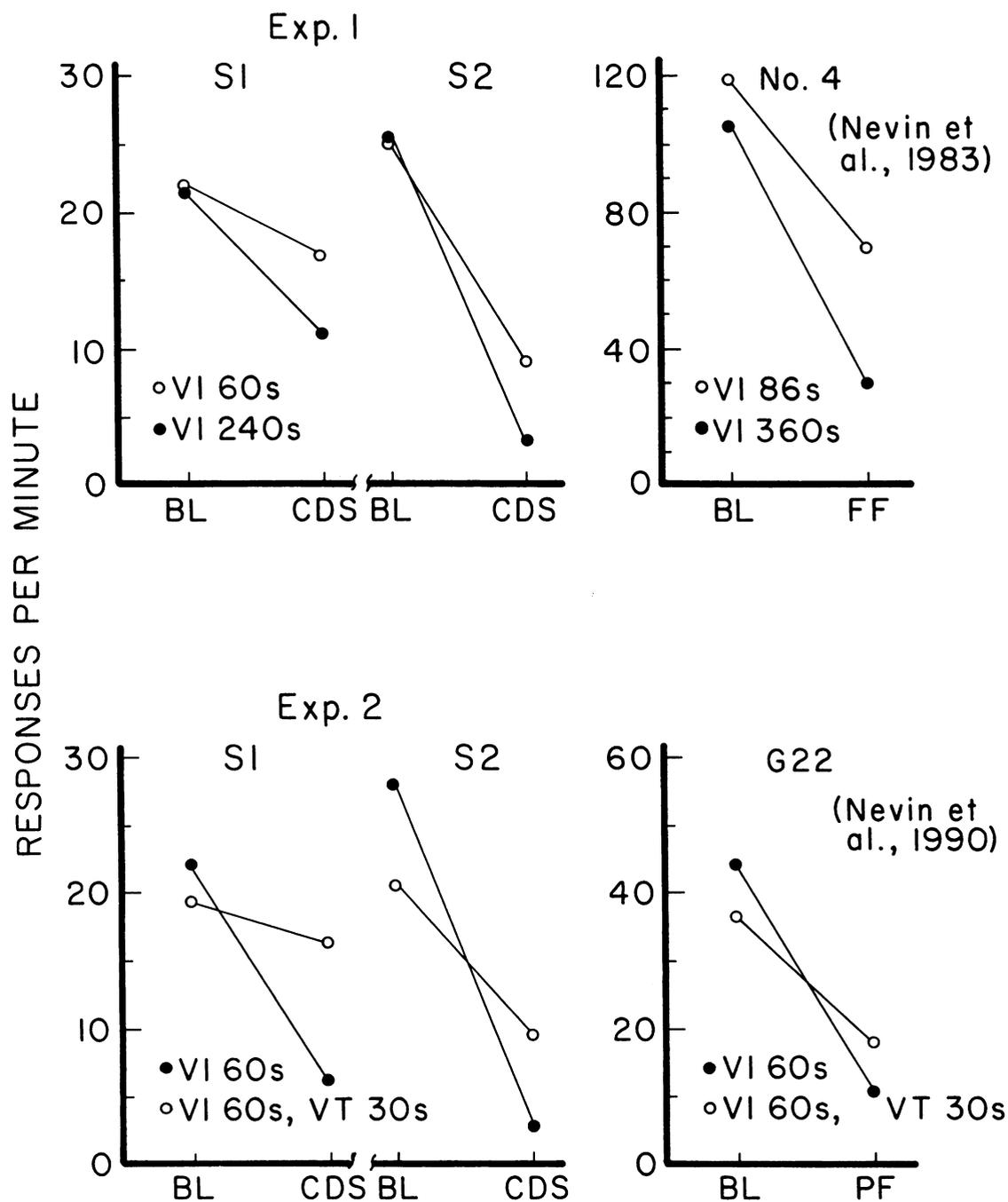


Fig. 3. Overall mean response rates across experimental phases (baseline, BL; concurrent distracting stimulus, CDS; free-feeding, FF; prefeeding, PF) during different two-component multiple schedules. The upper left panel summarizes the results of Part 1 of the present experiment with human subjects and is compared in the upper right panel to the performance of the median pigeon (No. 4) using a similar procedure from Nevin *et al.* (1983). The lower left panel summarizes the results of Part 2 of the present experiment with human subjects and is compared in the lower right panel to the performance of the median pigeon (G22) using a similar procedure from Nevin *et al.* (1990).

change is greater in the presence of the stimulus correlated with more frequent reinforcers. The result common to all these studies is that the persistence of responding in the presence of a distinctive stimulus is a positive function of the rate of reinforcer presentation correlated with that stimulus, regardless of differences in baseline response rates, response-reinforcer contingencies, and methods for assessing persistence.

The dependence of behavioral persistence on stimulus-reinforcer relations and its independence from response-reinforcer contingencies suggest that persistence (mass in the momentum metaphor) is related to Pavlovian processes. Some alternative theoretical interpretations are discussed in detail by Nevin et al. (1990) and will not be repeated here. For present purposes, the important result is the replication of well-established results for nonhuman subjects in controlled experimental settings with humans engaged in everyday tasks in a natural setting. Whatever the theoretical interpretation, these data show that the relations between resistance to change and the conditions of reinforcement have substantial generality and cannot be ascribed to biological preparedness of the sort that may be important for pigeons pecking lighted keys for food reinforcers.

These results also have some practical implications. Suppose, for example, that the sorting behavior of our subjects had been judged "undesirable" or "maladaptive," perhaps because it occurred at inappropriate times or occupied excessive time in the group home. Suppose further that there was no obvious external reinforcer maintaining it. Under these hypothetical conditions, a therapist seeking to reduce its frequency would be likely to arrange explicit reinforcers for some alternative behavior, as suggested by McDowell (1982, 1988). These reinforcers would probably decrease the frequency of sorting, but if they were delivered in the situation in which sorting occurred, they might well increase its persistence even though they were contingent upon a different class of behavior. To the extent that this outcome is likely, the therapist ought to consider options for decreasing sorting before implementing alternative reinforcement.

The likelihood of this outcome may depend on several factors that deserve explicit inves-

tigation. First, it may be that frequent and prolonged reinforcement for a topographically different alternative will enhance the persistence of the alternative as well as the persistence of sorting, perhaps leading to predominance of the alternative behavior after therapy terminates. Second, the enhanced persistence of sorting that results from explicit alternative reinforcement may depend on the relation between that reinforcer and the unknown reinforcer for sorting. We know from this study and related work with pigeons (Nevin et al., 1990) that an identical alternative reinforcer enhances resistance to change, but perhaps the effect would be reduced or even reversed if the reinforcers were different. These questions require experimental analysis, which is encouraged by the present demonstration that findings with nonhuman animals in the laboratory are replicable with humans in applied settings.

More generally, if it is true that behavioral persistence (mass) depends on stimulus-reinforcer relations and is independent of response-reinforcer contingencies (which determine velocity), some light may be shed on the oft-reported failures of persistence or generalization in applied settings (see Stokes & Baer, 1977). In their efforts to establish and maintain high rates of desirable behavior with response-reinforcer contingencies, applied workers may neglect stimulus-reinforcer relations. Conversely, if behavioral persistence is independent of response-reinforcer relations, the use of intermittent schedules to establish high, reliable response rates (e.g., Barton & Ascione, 1979) may be misplaced if one goal of treatment is to establish persistence. A joint program of basic and applied behavior analysis is needed to assess the determiners of behavioral mass and velocity, which together determine behavioral momentum.

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